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1975 PILOT PROJECT OF FENITROTHION FOR CONTROL OF WESTERN SPRUCE BUDWORM

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TABLE OF CONTENTS

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I. INTRODUCTION

The western spruce budworm, *Choristoneura occidentalis* Freeman, one of the most serious and persistent defoliators of western coniferous forests, has been present in outbreak numbers in the Washington Cascades since 1970.

The area of defoliation had increased from 240 acres in 1970 to 564,460 acres in 1974, with an additional increase predicted for 1975. A biological evaluation carried out in the fall of 1974 indicated that heavy damage would occur during 1975 in six entomological units in the Washington Cascades. These were Teanaway, Twisp River, Lookout Ridge - Gold Creek, Early Winters, Nason Creek, and Goat Peak. All these entomological units showed an increasing or static population for 1975.

Large-scale operational control was not recommended for 1975 because of the lack of an effective, Federally registered insecticide. Only Zectran® and Malathion® are registered for western spruce budworm control. Zectran is no longer being manufactured and Malathion has not proven effective for large-scale forest application. In an attempt to correct this situation, the Forest Service conducted a series of both large- and small-scale insecticide tests in both the West and East (Maine) during 1975.

Because of the increasing damage to Douglas-fir and true firs in the Washington Cascades during the last several years and the lack of an effective registered chemical for control, it has become necessary to develop additional chemical insecticides that could be used effectively against the spruce budworm. Fenitrothion has been reported to be effective against the eastern spruce budworm, *Choristoneura fumiferana* (Clemens). In addition, much of the environmental chemistry data necessary for registration had already been obtained during its use in Canada and Maine.

A steering committee was formed to assist in planning and coordination on the project. Randall Perkins of the Wenatchee National Forest was designated as chairman. This committee was composed of representatives of the Wenatchee and Okanogan National Forests, the Washington State Department of Natural Resources, Boise Cascade Corporation, Pack River Lumber Company, and Burlington Northern Railway. Since there were several research field studies being conducted at the same time, and accessible infested areas were somewhat limited, it was important to have all activities completely coordinated between the various landowners involved.

This document reports the planning, operations, and evaluation of the effectiveness of fenitrothion used against the western spruce budworm during 1975.

II. PROJECT OBJECTIVES

The objectives of this pilot project were to:

1. Determine if a single and double aerial application of fenitrothion will control an outbreak of western spruce budworm.

2. Determine if two aerial applications of fenitrothion will reduce budworm populations and preserve tree foliage significantly better than a single application under operational conditions.

3. Determine the effect of single and double aerial applications of fenitrothion on western spruce budworm parasites.

4. Determine the effect of single and double aerial applications of fenitrothion on non-target organisms, i.e. fish, aquatic invertebrates, and birds.

III. METHODS

A. The Chemical

The chemical used was fenitrothion (0,0-Dimethyl 0-(4-nitro-m-tolyl) phosphorothioate), an organophosphate insecticide. In its technical form it is a yellow-brown liquid with a specific gravity of 1.3227; it is insoluble in water but is miscible with most organic solvents. It is primarily a contact insecticide and acaricide with a low ovicidal capability.

The particular formulation of this chemical used was Sumithion ®, a product of the Sumitomo Chemical Comapany of Osaka, Japan. Other trade names for this chemical are Accothion ®, Folithion ®, MEP, Novathion ®, and Nuvanol ®.

Laboratory tests of Sumithion have shown no indications of tumorgenicity, mutagenicity, or teratogenicity. It inhibits cholinesterase activity in most animals. The acute oral toxicity for rats is 250 mg/kg and for mice 870 mg/kg which classifies it as moderately toxic. Dermal toxicity for mice exceeds 3,000 mg/kg.

Fenitrothion was tested at both a single and a double application rate. All applications were replicated three times. An additional three plots were established as untreated controls. Plot size varied from 1,172 acres to 1,528 acres. The large plot size used permitted adequate sampling of non-target organisms.

B. Selection of Treatment Areas

Areas to be used for testing were chosen primarily on the basis of budworm populations and lack of land use activities that would interfere with sampling during the two field seasons involved.

Individual plot treatments were determined by complete random selection. All nine plots were assigned random numbers and drawn separately for each treatment, including control plots. Following is a listing of plots by location, acreage and treatment:

Plot No.	Name	Legal Description	Acres	Treatment Received
1	Goat Wall	T. 36 N., R. 19 E., secs. 3,4,9,10 T. 37 N., R. 19 E., secs. 33,34	1,172	Single Application
2	Silver Star	T. 36 N., R. 18 E., secs. 26,27,34,35	1,200	None, control
3	Pekin Creek	T. 36 N., R. 19 E., secs. 29,30,31,32	1,200	None, control
4	Blackpine Lake	T. 33 N., R. 21 E., secs. 31,32	1,240	Single Application
5	Lookout Mountain	T. 33 N., R. 21 E., secs. 26,27,34,35	1,528	Double Application
6	Mission Creek	T. 32 N., R. 21 E., secs. 7,18	1,206	Single Application 1/
7	Teanaway Creek	T. 22 N., R. 15 E., secs. 13,14,23,24 T. 22 N., R. 16 E., secs. 18,19	1,275	Double Application
8	Standup Creek	T. 22 N., R. 16 E., secs. 28,33	1,200	None, control
9	Stafford Creek	T. 22 N., R. 16 E., secs. 24,25,26	1,190	Double Application

1/Only 1,056 acres treated due to accidental dump valve release of a partial load of chemical. However, all areas with effectiveness evaluation plots were treated.

Single application plots were treated with 3 ounces AI (actual ingredient) of fenitrothion in sufficient carrier to make 20 ounces of total formulation per acre. Double application plots were treated twice with 2 ounces AI of fenitrothion in 20 ounces of total formulation per acre. The carrier used in the formulation consisted of No. 2 fuel oil and Panasol AN-3, a heavy aromatic naptha solvent.

C. Spray Operations

1. Planning

Headquarters for the pilot project were located at the Twisp Ranger Station, Twisp, Washington. The District furnished a building which was used for both an office and a laboratory for foliage and larval checks. Separate space was provided for storage of field equipment. The North Cascades Smokejumper Base located near Twisp provided space within a fenced area for insecticide storage. Office equipment and miscellaneous other items were furnished by the Okanogan National Forest Supervisor's Office, Winthrop Ranger District, and Twisp Ranger District.

Arrangements were made through the Okanogan and Wenatchee National Forests for personnel, equipment and supplies. Funds were allocated to these Forests for these purposes.

Contracting for spray and observation helicopters was done through the Regional Office in Portland.

2. Personnel

At the peak of the project there were a total of 23 personnel employed as operational and entomological crews. With the exception of the Assistant Project Director, an employee of the Washington State Department of Natural Resources, all personnel were Forest Service employees.

In addition to the operational and entomological crews, there were approximately 14 people involved in execution of the environmental monitoring contracts, and five people involved as pilots and ground crew members on the aerial contract.

Of the Forest Service personnel on the project four permanent personnel were furnished by the Wenatchee National Forest, five were from the Regional Office in Portland, and the remainder were hired on a temporary basis by the Okanogan National Forest.

3. Equipment

A total of 14 vehicles were used on the project. Of these, five were commerical rentals provided by the Wenatchee National Forest, one entomologist used his personal vehicle on a mileage basis, three were Forest Service fleet vehicles, one was a Washington State Department of Natural Resources vehicle, and four were GSA motor pool vehicles.

An addendum to the Wenatchee National Forest contract for commercial vehicle lease provided for the five rental vehicles. These were a 1-ton stake truck, two 4-wheel drive pickups, a surburban carryall and a 2-wheel drive pickup.

4. Marking of Plot Boundaries

Two types of marking were used to identify plot boundaries. Each corner of each plot was marked with 3-feet by 6-feet flourescent orange or yellow plastic panels. These were attached to a fishing line at two corners and a slingshot was used to shoot a large washer attached to a line up over the top of a tree or snag close to the plot corner. The line was then pulled across the top of the tree until the panel was in place. It was then tied down on both sides of the tree to hold it in place.

The remainder of the boundary was then marked by throwing markers from a helicopter along a line between the corners. These markers consisted of a piece of heavy string about 6-feet long with plastic flourescent strips attached to it and large washers on each end. Five 6-inch by 5-foot strips of plastic were first stapled to the string, the whole package was then folded up and secured with a rubber band. These were thrown out of the helicopter in such a way so as to wrap loosely around the top or over an upper limb of a tree or snag. If more than 10 days elapsed or a strong wind had blown between marking and spraying, it was necessary to remark some areas. Pilots report that this system of marking is easy to follow when spraying, even on large plots.

5. Formulation of Insecticide

The insecticide was formulated in the field using a 200 gallon mix tank with a recirculation pump and plumbing system. The fenitrothion was pumped into the tank first. Solvent was then added to aid in getting the insecticide in solution with the fuel oil. 3.8 grams of Rhodamine B red dye, in powder form, was added per gallon of final mixture for spray deposit analysis purposes. The mixture was then recirculated for about 5 minutes before the No. 2 fuel oil was added. The entire mixture was then recirculated for about 5 more minutes.

The formulations for the single and double application were as follows:

Double Application

Material	Amount	% of Mixture
Fenitrothion	1.5 fluid ozs. (2 ozs. by weight)	7.50
HAN Solvent[1/]	3.8 fluid ozs.	19.00
No. 2 fuel oil	14.7 fluid ozs.	73.50
TOTALS	20.0 fluid ozs. per acre	100.00

Plus Rhodamine B red dye - .59 grams per acre.

1/The heavy aromatic naptha (HAN) solvent used was Panasol AN-3 produced by the American Oil Company.

Single Application

Fenitrothion	2.25 fluid ozs. (3 ozs. by weight)	11.25
HAN Solvent1/	5.70 fluid ozs.	28.50
No. 2 fuel oil	12.05 fluid ozs.	60.25
TOTALS	20.00 fluid ozs.	100.00

Plus Rhodamine B red dye - .59 grams per acre.

1/The heavy aromatic naptha (HAN) solvent used was Panasol AN-3 produced by the American Oil Company.

One problem arose in mixing that may have slightly affected the results on the three double application plots. It was discovered at the end of the first barrel of insecticide that the barrel pump meter was reading about 11 percent high. A correction factor was used from that point on, but apparently the amount of insecticide on the first of the double applications was about 11 percent less than planned, or 1.78 ounces per acre rather than 2 ounces per acre.

In order to determine the toxic effects of the solvent and how it might effect the results of the insecticide test, samples of the solvent and the No. 2 fuel oil were sent to the Insecticide Evaluation Project at Berkeley, California for determination of toxicity. Tests were carried out on the same mixture that was used for the double application plots, since this included more solvent and fuel oil than the mixture used on the single application plots. Spruce budworm mortality for this mixture was 2.5 percent. Doubling the volume of the mixture doubled the percent mortality to 5 percent, which was not a significant increase. Less than 10 percent bioassay mortality cannot be separated from mortality due to natural causes, therefore the percent mortality caused by the carrier can be considered insignificant.

6. Timing of Spray Application

Proper timing of the application of the insecticide was vital for the pilot test to be successful. If the fenitrothion was applied too early, it would not contact the budworm larvae feeding safely within the unopen bud. Also as the buds opened, new unsprayed foliage would be available for budworm feeding. If the application of the insecticide was delayed too long, the budworms would have pupated and within the pupa case would be safe from contact by the spray.

Within the test plots there was a variation in elevation and exposure creating a spread in the rate of larval development. Such conditions made it impossible to apply the fenitrothion to all larvae at the optimum time. Therefore, the spray was applied when the majority of the budworm larvae on each plot was at the most receptive stage.

On each treatment and check plot, 25 development stations were located. These were representative of elevation changes and exposure of the terrain on the plot. Foliage at each station was examined at intervals to determine when the larvae had started to break hibernation and mine the buds. Approximately 2 weeks later regular larval development sampling started on one tree at each station. Two 15-inch branches were clipped from the mid-crown of each tree, tagged and placed in a plastic bag and taken to the field laboratory. In the laboratory all the larvae were collected from these branches and their instar determined by Carolin's method of using head capsule characteristics and head width measurements. The percentage of larvae having reached the fifth instar was plotted on a graph and as this figure approached the percentage required for spraying the sampling was repeated daily. When the target percentage was reached the plot was released for spraying 3 days later.

During this pilot project, plots receiving one application were sprayed 3 days after 75 percent of the larvae were in the fifth instar or larger. Test plots receiving two applications were sprayed first 3 days after 25 percent of the larvae had reached the fifth instar or larger. The second application was made 7 days later.

7. Application

The application contract bid invitation provided for accepting bids from either fixed-wing operators or helicopter operators. As a separate contract item, a helicopter was required for observation of the spraying, regardless of whether the application aircraft were fixed-wing or helicopter. Cascade Helicopters, Inc. of Cashmere, Washington was the successful bidder on both items.

The contract application required the aircraft furnished to have the capability of spraying 500 acres per hour at the rate of 20 ounces per acre. Because of the low rate of application it was decided that one helicopter of the Bell 47G3B-1 class could meet the contract requirement, since in most cases only four loads were needed to complete a plot. This low rate of application reduced the loading and ferry time. This standard of 500 acres per hour was not attained, but due to favorable spraying conditions, all spraying was completed on schedule (see Table 2).

Following is a list of bidders on the contract and the bid amounts:

Bidder	Rate Per Move	Application Per Acre	Observation Per Hour	Total Application Bid	Total Observation Bid	Type Aircraft
Cascade Helicopters	$200	$ .93	$159.00	$10,300	$ 6,360	Helicopter
Agro-Aviation	$175	$1.25		$13,375		Fixed-wing
Johnson Flying Service	$500	$1.94	$175.00	$21,900	$ 7,000	Helicopter
Western Helicopters	$200	$2.80	$380.00	$29,000	$15,200	Helicopter
Columbia Flying Service	$205	$4.50		$46,025		Fixed-wing

Significant features of the aerial application contract were:

(a) Contractor to provide aircraft capable of spraying 500 acres per hour for application of fenitrothion to approximately 10,000 acres.

(b) Payment to be based on number of acres treated.

(c) Contractor to provide personnel to formulate material under Forest Service supervision.

(d) Contractor to furnish 500 gallon tank truck with recirculating capabilities and metering devices.

(e) Contractor guaranteed $200.00 per calendar day if helicopter held by Forest Service for its exclusive use.

(f) Contractor to furnish approximately 1,100 gallons of No. 2 fuel oil as a carrier for the insecticide.

(g) Contractor to make available his personnel who handle or are exposed to insecticide for cholinesterase blood tests.

(h) Forest Service to provide medical services to contractor's personnel for determination of cholinesterase levels.

(i) Forest Service to guarantee 40 hours flight time for observation helicopter.

(j) Forest Service to furnish insecticide, dyes, and heavy aromatic solvent for mixing with insecticide.

(k) Forest Service to delineate areas to be treated by ground markers and/or a qualified person to fly with pilot on reconnaissance flights to locate and delineate boundaries.

(l) A change order to the contract specified the use of Beecomist nozzles which the contractor furnished. The original contract provided that T-Jet flat fan nozzle tips would be furnished by the Forest Service.

A Bell 47G3B-1 spray helicopter was furnished by the contractor and calibrated to deliver the finished insecticide at a rate of 20 ounces per acre with a droplet size of approximately 150 microns volume median diameter (Vmd) delivered at 60 miles per hour. After consultation with various chemical company representatives, helicopter operators and personnel for the Forest Service's Aerial Application Project (PNW-2208) at Corvallis, Oregon; a decision was made to use "Beecomist" nozzles rather than T-Jet flat fan nozzles. The advantages of this nozzle over others is that droplet size does not vary with the speed of the aircraft and is more uniform. When using these nozzles, it is also possible to obtain a smaller droplet size with more viscous materials. The perforated metal sleeve used with this nozzle provided a capacity of over 6 gallons per minute. Three nozzles were used, one near each end of a 40-foot boom and one under the fuselage of the helicopter. This arrangement provided a 100-foot effective swath width as determined by spray cards placed on the ground.

Spray was applied at an airspeed of 60 miles per hour and at an altitude of about 50 feet above the crown canopy. During spray application, average windspeed never exceeded 3 miles per hour, and except for one plot, average temperature never exceeded 70° F. The temperature on the Mission Creek plot was 75° F. at 0430 so a test run was made to check settling of the spray. Since it was dropping into the trees satisfactorily, the Project Director instructed spraying to start. The temperature gradually lowered to 72° F. while application took place and close observation of the spray cloud indicated no problems with regard to settling of the spray. During the application on this same plot the pilot inadvertently hit the spray dump valve after he had sprayed about one-half of his load. Approximately 23 gallons of material was dumped and spilled on the side of a rocky ridge. This was over 1/4 mile from the nearest stream course and not on any of the effectiveness evaluation clusters. No adverse environmental effects were detected.

The average windspeed during spraying was less than 2 miles per hour. Maximum wind in short gusts was about 9 miles per hour. The greatest weather problems encountered were rain and high temperatures. Blackpine Lake and Goat Wall plots were sprayed with temperatures approaching 70° F. but no adverse effects from the high temperatures occurred. The last week of spraying was a period of unseasonably hot weather in the spray area. One phenomena that occurred regularly during the hot spell was a drop in

temperature from the time spraying started (about 0445) until the plot was completed (about 0900). On all but the Mission Creek plot it was possible to complete most of the treatment on each plot before temperatures exceeded 70° F.

A brief description of plot treatment conditions follows:

Single Treatment Plots

Plot No. 1 - Goat Wall: Size: 1,172 acres. Treatment Date: July 11, 1975. Average Elevation: 6,000 feet. Aspect: Northwest. Weather: Cloudy, thunderstorms about 10 miles to the west of plot, average windspeed less than 2 miles per hour, maximum gusts of 5 miles per hour. Temperature during spraying ranged from 69° to 72° F.; average 70° F. No rain on plot within 24 hours of spraying.

Plot No. 4 - Blackpine Lake: Size: 1,240 acres. Treatment Date: July 9, 1975. Average Elevation: 3,600 feet. Aspect: North. Weather: Clear, average windspeed 2 miles per hour, maximum gusts of 5 miles per hour. Temperature during spraying ranged from 67° to 70° F.; average temperature 68° F. No rain on plot within 24 hours of spraying.

Plot No. 6 - Mission Creek: Size: 1,206 acres of which 1,056 acres were actually treated. Treatment Date: July 6, 1975. Average Elevation: 4,600 feet. Aspect: East. Weather: Partly cloudy, average windspeed less than 2 miles per hour, maximum gusts of 2 miles per hour. Temperature during spraying ranged from 72° to 81° F.; average temperature 74° F. An estimated 0.1-inch of rain fell on this plot during a thunderstorm about 1 hour after spraying was completed.

Double Application Plots

Plot No. 5 - Lookout Mountain: Size: 1,528 acres. Treatment Dates: June 25, 1975 and July 2, 1975. Average Elevation: 4,000 feet. Aspect: East and west. First Application Weather: Partly cloudy, average windspeed less than 2 miles per hour, maximum gusts of 7 miles per hour. Temperature ranged from 42° to 54° F.; average temperature 47°F. Light rain fell on the plot about 5 hours after the first application was completed.

Second Application Weather: Partly cloudy, average windspeed was about 2 miles per hour with maximum gusts of 7 miles per hour. Temperature during spraying ranged from 53° to 61° F.; average temperature 56° F. A heavy thunderstorm occurred on the plot about 10 minutes before the second application was completed. Some parts of the plot received heavy rain for about 15 minutes. Other parts only a few drops.

Plot No. 7 - Teanaway Creek: Size: 1,275 acres. Treatment Dates: June 30, 1975 and July 7, 1975. Average Elevation: 4,000 feet. Aspect: Northeast and southwest. First Application Weather: Scattered clouds, average windspeed was less than 2 miles per hour, maximum gusts of 5 miles per hour. Temperature during spraying ranged from 36° to 53° F.; average temperature 41° F. No rain on this plot within 24 hours after the first application was completed.

Second Application Weather: Clear, average windspeed less than 2 miles per hour, maximum gusts of 5 miles per hour. Temperature during spraying ranged from 53° to 73° F.; average temperature 58° F. A light rain fell on this plot about 2 hours after the second application was completed.

Plot No. 9 - Stafford Creek: Size: 1,190 acres. Treatment Dates: July 1, 1975 and July 8, 1975. Average Elevation: 4,000 feet. Aspect: North and south. First Application Weather: Cloudy, average windspeed less than 2 miles per hour, maximum gusts of 3 miles per hour. Temperature during spraying ranged from 48° to 63° F.; average temperature 52° F. A light rain fell on this plot about 2 hours after the first application was completed.

Second Application Weather: Clear, average windspeed less than 2 miles per hour, maximum gusts of 6 miles per hour. Temperature during spraying ranged from 57° to 72° F.; average temperature 61° F. No rain fell on this plot within 24 hours of completing the second application.

A total of 7,461 acres were treated in the six plots. Including the double application on three plots, fenitrothion treatment was applied to 11,454 acres.

All applications except Mission Creek, plot no. 6, were observed by a trained aerial observer in a separate helicopter flying above and with the application helicopter. On the day of spraying Mission Creek, the observation helicopter had to be used to spray research plots in the vicinity in order to meet the spray schedule for those plots. However, the heliport at the Mission Creek plot overlooked about two-thirds of the plot and spraying was observed from the ground during most of the application.

D. Safety and Insecticide Handling

One personal injury occurred on this project when a crew member cut her hand trying to retreive a pruning pole which had slipped from her grasp. No lost time was involved.

Two motor vehicle accidents occurred during the project. Both occurred late in the project when field crews were doing 20-day postspray sampling, and were caused by hitting stumps in the field. Damage was minor in both cases and no injuries resulted.

All insecticide barrels were stored in a fenced area at the North Cascades Smokejumper Base and no accidents or vandalism occurred. All empty barrels were disposed of at a State approved disposal site near Twisp, Washington.

A full-time Safety Officer on the project assured that the safety plan was modified as necessary to meet local conditions and that all personnel were aware of hazards and followed proper safety procedures. The benefits of having this position are evident in the excellent safety record on the project.

IV. ENVIRONMENTAL MONITORING

Two contracts were awarded for environmental monitoring of the fenitrothion application. One was to the Washington State Department of Ecology for:

(a) The determination of measurable amounts of fenitrothion in the aquatic environment through sample analysis.

(b) The assessment of measureable impacts of fenitrothion on aquatic organisms, including but not limited to, benthic invertebrates and native fish.

Although there appeared to be a detectable impact on the aquatic environment at threshold levels resulting from the 1975 Spruce Budworm Spray Project, it was concluded that no measurable environmental damage was incurred by the aquatic biota of the program streams. Of the six spray applications monitored that involved watercourses, mortalities resulting from the fenitrothion spray project were noted only in live boxes at one station on Poormans Creek. No insect mortalities were noted in the free flowing stream or in the drift insect samples that could be attributed to the aerial spray project.

It was also concluded that aquatic insects, particularly mayflies, are quite sensitive to fenitrothion at relatively low concentrations. A high degree of buffer protection is recommended for fenitrothion application rates in excess of three ounces per acre.

The second contract was to the Washington State Department of Game for:

(a) A songbird census in treated and untreated areas.

(b) The determination of the number of dead songbirds, if any, on treated and untreated plots at whatever interval was jointly determined to be necessary.

(c) The collection and analysis of 10 each of the three species of songbirds (warblers, chickadees, and either juncos or siskins) on three treated areas for brain tissue cholinesterase levels before and after treatment.

Systematic searches produced no dead or distressed birds suspect of having been poisoned with fenitrothion. No nestling mortality was observed in a large sample, and many nestlings present at the time of spray fledged subsequently. No acetylcholinesterase level depression was evident. Differences in pre- and postspray territorial indices were not great and the conclusion was that no bird mortality occurred on the study plots as a result of fenitrothion effects.

A separate study of the effects of the insecticide on spruce budworm parasites was carried out by the Forest Service. In this study, 30 larvae were collected for each sample tree in a cluster during prespray and postspray sampling periods. Larvae from each tree were then placed in petri dishes and reared on an artificial diet to determine the number and diversity of parasites. No significant differences were observed in the number and species of parasites between treated and untreated plots.

V. COST

The total cost of carrying out this pilot project was $158,671.90. This does not include approximately $40,000.00 contributed by permanent Forest Service and Washington State Department of Natural Resources personnel. The cost on a per acre basis was $13.85.

The largest single cost item on this project was environmental monitoring. The cost of monitoring contracts was $3.68 per acre, with an additional estimated cost of $.38 per acre for administration and coordination of the monitoring program. Other higher than normal costs for this project, as compared to a control project, involved plot location, marking, and development, prespray and postspray sampling. These costs totaled approximately $5.50 per acre which is considerably higher than they would be on a control project.

All other treatment costs totaled about $4.29 per acre.

Table 1 in the appendix shows a complete breakdown of project costs.

VI. RESULTS

A. Effectiveness Determination Procedures

Budworm and foliage sampling procedures were used to determine effectiveness as follows:

1. The budworm population was determined on each plot when 25 percent of the population had reached the fifth instar or larger and prior to the application of the insecticide.

2. The degree of defoliation that had occurred to the current year's foliage at the time the prespray budworm population was estimated.

3. A postspray budworm population count was made on each plot 20 days after the prespray population was determined.

4. The degree of defoliation on the current year's foliage as a result of 1975 budworm feeding was determined on all plots.

Budworm populations, both pre- and postspray, were sampled using a tree cluster method. Twenty-five clusters of three trees each were selected in each test plot. Sample trees were Douglas-fir or grand fir, 30 to 50 feet tall, selected in such a way as to provide a representative sample of foliage within the plot.

The prespray population was determined by collecting two branches approximately 15 inches long from as close to mid-crown of the sample tree as practical. The number of current year's shoots or buds per branch were counted as well as the number of live budworm larvae present. The population estimate was expressed as the number of budworm larvae per 100 new shoots or buds.

The postspray population sample was similar to the prespray except that four branches were collected from each sample tree instead of two. These branches were also collected at mid-crown. The postspray sample was doubled because a low level budworm population level was expected after spraying. Budworm were mostly in the pupae stage at this period, but the few live larvae and pupae cases present from recently emerged moths were included in this postspray count.

Prespray population counts were made when it was determined that 25 percent of the budworm population had reached the fifth instar or larger. The postspray samples were made 20 days after the prespray count. On the plots that received two insecticide applications, in addition to the 20-day sample, a count was made 5 days after the first insecticide application.

Budworm defoliation damage assessment made prior to insecticide application was made on the same branches used to sample the prespray budworm population. Postspray damage assessment was not made until early August when all the budworm feeding had been completed for the year. This necessitated the clipping of four additional branches per tree. Each branch was collected, placed in an individual plastic bag, labeled, and put in cold storage (34 to 38° F) at the field laboratory until examined.

The apical 25 buds were examined on each branch, a total of 50 buds on the prespray survey per tree and 100 buds or new shoots per tree during the postspray survey. Damage was estimated to the nearest 10 percent for each bud or new shoot examined. The total amount of defoliation was computed and recorded by individual branch.

To assess the volume of insecticide deposited at each sample tree, two white Kromekote cards in plastic card holders were placed on the ground on opposite sides of the tree in the nearest open area. Cards were placed each morning just before spray application and picked up within 2 hours after spraying was completed.

B. Budworm Population Reduction

Prespray budworm populations on the test plots ranged from 25.7 to 55.8 larvae per 100 buds (Table 6). For a successful treatment, the budworm population needed to be reduced to 1 pupae or less per 100 buds at the time of the final postspray sample. One pupae per 100 buds indicates a budworm population of 5 larvae will be present in the buds the following spring, using the criteria presented by Carolin and Coulter (1972).

Mean postspray budworm populations, mostly in the pupal stage, ranged from 6.8 to 13.6 per 100 buds on the treated plots (Table 6). When the budworm population level wajs adusted to a common prespray population density by analysis of covariance the adjusted postspray budworm density was 9.4 pupae per 100 new shoots on the plots receiving a single spray application and 10.9 on the plots receiving two applications. Pupal populations of this density would result in 30 to 80 larvae per 100 buds in 1976 unless a significant natural reduction would occur in the budworm population between the pupal stage and entry of the larvae into the buds. Therefore, based on the budworm population reduction obtained, both the one and two application treatments were unsuccessful.

Previous budworm control projects have been evaluated using the percentage of reduction occurring to the budworm population between the pre- and postspray population counts. The results of these projects varied between 90 and 98 percent mortality depending on such factors as: Insecticide used, rate of application, type of terrain, and density of infestation. All the fenitrothion applications were a failure based on this criterion as the unadjusted population reduction was only 74.5 and 75.9 percent. Natural mortality during the same period was 69.1 percent (Table 7). When the budworm population level was adjusted to a common prespray population density by analysis of covariance, the corrected mortality was only 17.4 percent on the plots receiving two fenitrothion applications and 28.8 percent on those receiving one (Table 8). Although these figures are not significantly different they also tend to indicate ineffectiveness.

C. Foliage Protection

Prespray budworm populations on all plots were at a density that if left untreated should have caused defoliation in the heavy category (Table 9). Defoliation recorded on the untreated plots was 95.5 percent which is within the very heavy category. The single application plots were 63.7 percent defoliated and the double application plots 87.9 percent. Although both of these defoliation levels are well within the heavy category, approximately a third of the current year's foliage was saved by one application of 3 ounces of fenitrothion.

Using a postspray budworm density, adjusted to a common prespray density, the adjusted degree of defoliation was reduced but was still very heavy on the check plots and the double application plots and heavy on the single application plots (Table 8). There was a significant (F = 20.3 at

p = .01) difference in the level of defoliation between the plots receiving single or double spray applications. The plots receiving two spray applications had more defoliation as was expected since the mortality rate was lower. The residual number of surviving budworm was higher on these plots (Table 8). However, this could also be attributed to the 82 percent greater budworm density on the double application plots before spraying.

One 3 ounce per acre application of fenitrothion saved more foliage than 2 ounces applied twice, but neither saved enough foliage to warrant the cost of treatment unless the budworm mortality that occurred would result in the prevention of further defoliation during 1976. This is not likely to occur since the surviving budworm population in the pupae stage indicates a larval population great enough to cause heavy defoliation in 1976.

D. Spray Deposit (Table 10, Appendix)

The average amount of material applied was 20 ounces or .156 gallons per acre. Spray cards on the single application plots received about 6 percent of this amount, the cards on the first of the double application received approximately 18 percent, and the cards on the second of the double application received about 8 percent of the total material applied. These figures are not significant because of the probability of large errors in estimating gallons per acre using the quantimat 720. Reasons for errors in using the quantimat 720 for estimating gallons per acre of deposit are: 1. The spread factor can be calculated to only about a 10 to 20 percent accuracy level, and 2. If drops are not spherical or the have a "halo" effect caused by moisture content of spray cards, it is difficult for the machine to accurately size the drops. This may be one of the reasons there is very little correlation between amount of spray deposit and insect mortality.

Another factor affecting the amount of spray deposit on the cards is the great variation in amount of foliage intercepting insecticide above the spray cards. In many cases, no openings were available in which to place spray cards.

On the other hand, there seems to be a correlation between spray droplet size and insect mortality. Droplet sizes averaged 120 microns on the single application plots, and 145 microns on both of the double application plots. This compares favorably with the goal of 150 microns for the project.

The difference in droplet size of 25 microns between the single application and the double application may or may not be significant. Whether the increased insect mortality on the single application plots is due to this difference in droplet size or due to other factors, is not known.

VII. COOPERATION

This project was a cooperative effort between Region 6 of the Forest Service, Pacific Northwest Forest and Range Experiment Station, State of Washington and several private landowners.

The Aerial Application Project of the Pacific Northwest Forest and Range Experiment Station provided application and formulation technical assistance. The Washington State Department of Natural Resources provided project planning and entomological assistance as well as one man full-time on the project to act as Assistant Project Director and Environmental Monitoring Coordinator.

The Washington State Departments of Game and Ecology conducted the environmental monitoring. The Washington State Department of Agriculture provided pesticide and pesticide container disposal assistance.

Several large private owners in the area including Boise Cascade, Pack River Lumber Company, and Burlington Northern Railway cooperated in making their lands available for use on this project as well as for several small tests of other chemicals.

VIII. REFERENCES

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IX. APPENDIX

[illegible] Introduction [illegible]

[illegible] During Treatment [illegible]

[illegible] Before and After Spraying [illegible] Replacement [illegible]

[illegible] with [illegible]

[illegible] and Degree of [illegible] Levels [illegible] Analysis

[illegible]

[illegible] Larvae, or Pupae Required to Cause These [illegible]

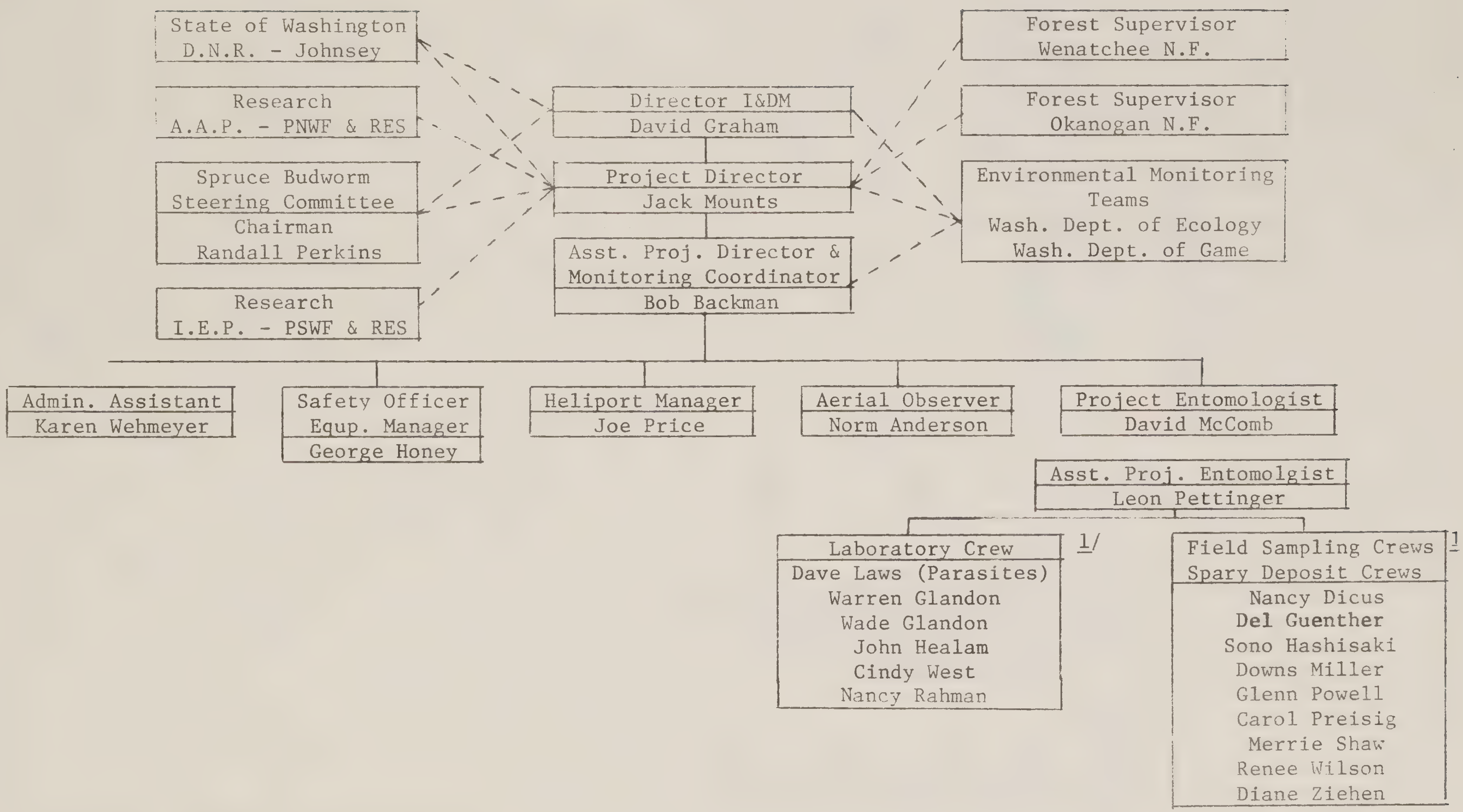
[illegible]

Map of [illegible] Area Plots

Map of [illegible] Area Plots

Figure 1 - Organization Chart

1975 Spruce Budworm Pilot Project



1/ These crews were interchangeable

TABLE 1

Project Cost Summary

	Total Cost	Cost/Acre
Insecticide (Sumithion)Including Transportation	$ 10,069.65	$ .879
Solvent (Panasol AN-3, Heavy Aromatic Naptha Solvent)	1,121.28	.098
Application (including No. 2 fuel oil carrier)	11,459.82	1.000
Observation and Reconnaissance	10,176.00	.888
Salaries	34,809.46	3.039
Per Diem and Travel	15,360.24	1.341
Equipment Use	9,183.80	.802
Miscellaneous Purchases including rents, utilities, etc.	12,315.85	1.075
ADP Data Analysis (Estimate)	1,500.00	.131
Environmental Monitoring	42,120.00	3.677
Final Report Preparation (Estimate)	3,000.00	.262
Subtotal	151,116.10	13.192
5% RO Overhead	7,555.80	.660
GRAND TOTAL	158,671.90	13.852

TABLE 2

Progress of Treatment

Date of Application	Area	Flight Hrs.	Acres Treated	Acres/ Hr.
6/25	Lookout Mtn. #5	4'03"	1,528	372.7
6/30	Teanaway Creek #7	2'53"	1,275	439.7
7/1	Stafford Creek #9	3'02"	1,190	396.7
7/2	Lookout Mtn. #5	3'18"	1,528	463.0
7/6	Mission Creek #6	2'30"	1,056 1/	422.4
7/7	Teanaway Creek #7	3'14"	1,275	398.4
7/8	Stafford Creek #9	2'40"	1,190	440.7
7/9	Blackpine Lake #4	2'36"	1,240	476.9
7/11	Goat Wall #1	2'52"	1,172	404.1
	TOTALS	27'08"	11,454	

1/ Plot was actually 1,206 acres but 1/2 load was dumped, reducing acreage treated by 150 acres.

TABLE 3

Observation Helicopter Flight Hours

Date	Type of Flight	Hours
6/3	Reconnaissance	2.1
6/4	Reconnaissance	1.6
6/5	Reconnaissance	3.8
6/9	Reconnaissance	2.4
6/10	Reconnaissance	1.4
6/10	Ferry	1.7
6/11	Reconnaissance	1.9
6/11	Ferry	0.6
6/23	Ferry	1.0
6/23	Reconnaissance	2.6
6/25	Observation	5.0
6/25	Ferry	1.0
6/26	Reconnaissance	1.0
6/29	Ferry	0.6
6/29	Reconnaissance	1.3
6/30	Observation	3.3
6/30	Ferry	1.6
7/1	Ferry	1.7
7/1	Observation	3.5
7/2	Observation	4.2
7/3	Reconnaissance	1.5
7/6	Observation	0.4
7/6	Ferry	1.9
7/7	Observation	3.4
7/8	Observation	3.1
7/8	Ferry	1.8
7/9	Observation	3.6
7/10	Reconnaissance	1.6
7/11	Observation	5.8
7/11	Ferry	1.2

Total Reconnaissance -	21.2
Total Ferry Time -	11.5
Total Observation -	32.3
	65.0

TABLE 4

Aircraft Production

Spray Helicopter

Helicopter Spray Days = 9

Acres per Flight Day = $\frac{11,454}{9}$ = 1,272.7

Average Hrs./Flight Day = $\frac{27.1}{9}$ = 3.0

Acres/Hour (Total Flight Time) = $\frac{11,454}{27.1}$ = 422.7

Observation Helicopter

Helicopter Days = 19

Average Hrs./Flight Day = $\frac{65}{19}$ = 3.4

TABLE 5

Weather Records During Treatment

Date	Area Treated	Time of First Observation	Time of Last Observation	Average Wind Velocity 1/	Maximum Wind Velocity	Temp. 2/ Range	Remarks
6/25	Lookout Mtn. #5	0420	1000	2	7	42-54	Light rain, + 5 hrs.
6/30	Teanaway Creek #7	0430	0815	2	5	36-53	
7/1	Stafford Creek #9	0445	0825	2	3	48-63	Light showers + 2 hrs.
7/2	Lookout Mtn. #5	0416	0830	2	7	53-61	Hvy. showers at end of spraying
7/6	Mission Creek #6	0445	0815	2	2	72-81	Hvy. showers + 1 hrs.
7/7	Teanaway Creek #7	0430	0900	2	5	53-73	Light shower + 2 hrs.
7/8	Stafford Creek #9	0430	0830	2	6	57-72	
7/9	Blackpine Lake #4	0430	0800	2	5	67-70	
7/11	Goat Wall #1	0415	0845	2	5	69-72	

1/ Wind velocity meter used did not record winds of less than 2 miles per hour.

2/ Higher readings taken after spraying was completed in most cases.

TABLE 6

Western Spruce Budworm Populations Before and After Spraying With One and Two Applications of Fenitrothion

Number of Applications	Plot No.	Prespray 1/ Mean 3/	Prespray 1/ Standard Error	Postspray 2/ Mean 4/	Postspray 2/ Standard Error
1	1	28.6	± 1.74	7.0	± .55
1	4	31.4	± 2.99	8.1	± 1.30
1	6	25.7	± 2.50	6.8	± .71
2	5	54.8	± 4.80	13.6	± 1.18
2	7	51.4	± 2.98	12.2	± 1.10
2	9	50.8	± 3.97	12.1	± 1.71
Check	2	36.2	± 5.78	13.0	± 1.99
Check	3	39.9	± 3.53	11.7	± 1.67
Check	8	55.8	± 3.65	16.0	± 1.69

1/Taken when 25 percent were in the fifth instar or larger.

2/Postspray count taken 20 days after the prespray count.

3/Number of larvae per 100 buds.

4/Number of pupae and larvae per 100 buds or new shoots.

TABLE 7

Budworm Population Reduction and Degree of Defoliation on Plots Treated With Fenitrothion

Treatment	Prespray 1/ Population	Postspray 2/ Population	Percent Reduction	Percent 3/ Defoliation
Single	28.6	7.3	74.5	63.7
Double	52.3	12.6	75.9	87.9
Check	44.0	13.6	69.1	95.5

1/Budworm larvae per 100 buds.

2/Budworm larvae and pupae per 100 buds or new shoots.

3/Percent of current year's foliage destroyed by budworm feeding.

TABLE 8

Budworm Population Reduction and Degree of Defoliation Levels Adjusted to a Common Prespray Population Density By Analysis of Covariance

Treatment	Common Prespray 1/ Budworm Density	Adjusted Postspray 2/ Budworm Density	Corrected Mortality	Adjusted 3/ Defoliation
Single	41.6	9.4	28.8	67.7
Double	41.6	10.9	17.4	84.8
Check	41.6	13.2		94.8

1/Budworm larvae per 100 buds.

2/Budworm larvae and pupae per 100 buds or new shoots.

3/Percent of current year's foliage destroyed by budworm feeding.

TABLE 9

Standard Categories of Defoliation to Douglas-fir and the Levels of Eggs, Larvae, or Pupae Required to Cause These Categories of Damage. 1/

Defoliation Category	Percent	Eggs Per 1,000 sq. in.	Larvae Per 100 buds	Pupae Per 100 shoots
Very Light	0 - 15	0.0 - 1.9	0.0 - 7.5	0.0 - 1.5
Light	16 - 25	2.0 - 4.2	7.6 - 13.5	1.6 - 2.5
Moderate	26 - 50	4.3 - 10.0	13.6 - 28.5	2.6 - 5.7
Heavy	51 - 90	10.1 - 19.2	28.6 - 52.4	5.8 - 10.5
Very Heavy	91 - 100	19.3 & up	52.5 & up	10.6 & up

1/Adapted from Carolin and Coulter's PNW Research Paper-149 (1972).

TABLE 10

Spray Deposit Means

Plot Name	Treatment	Plot No.	No. Observations	Average VMD1/	Average GPA2/	Average Drops/Sq. Cm.3/	Insect Mortality Percent4/
Goat Wall	1	1	150	116.79	.0073	2.710	
Blackpine Lake	1	4	150	117.32	.0082	2.726	
Mission Creek	1	6	145	127.39	.0139	2.876	
Average			148	120.50	.0098	2.770	77.4
Lookout Mtn.	2-1	5	118	118.37	.0084	3.043	
Teanaway Creek	2-1	7	142	141.50	.0261	3.877	
Stafford Creek	2-1	9	137	175.24	.0485	5.319	
Average			132	145.04	.0277	4.080	
Lookout Mtn.	2-2	5	145	160.03	.0176	2.967	
Teanaway Creek	2-2	7	150	134.91	.0078	1.527	
Stafford Creek	2-2	9	149	141.48	.0132	3.367	
Average			148	145.47	.0129	2.620	73.8
Average Single Application				120.50	.0098	2.770	
Average Double Application				145.25	.0203	3.350	

1/Volume Mean Diameter of spray droplets.

2/Gallons per acre of deposit.

3/Average drops per square centimeter deposited on centers of spray cards.

4/Adjusted to common prespray population density.

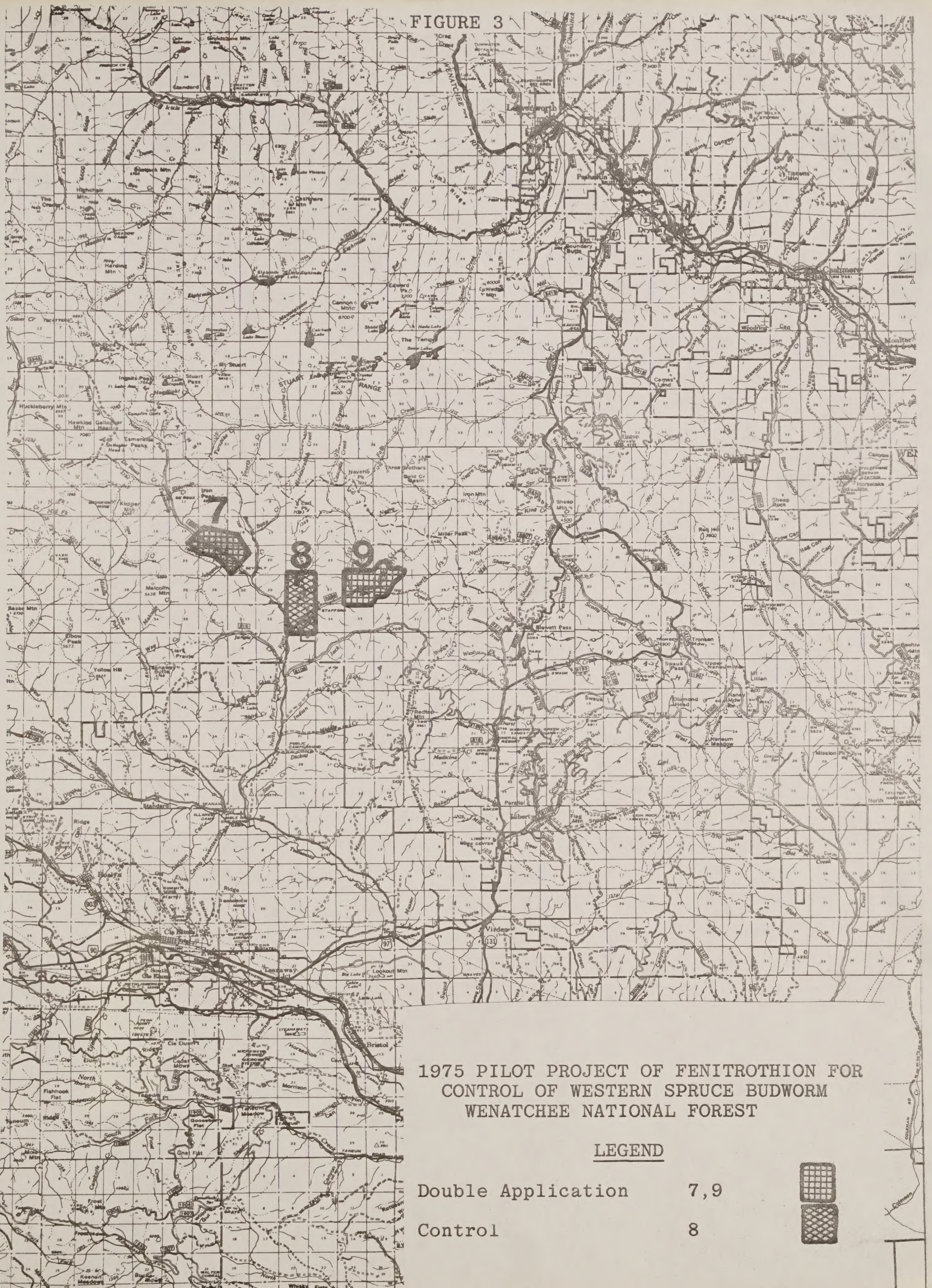
FIGURE 2

1975 PILOT PROJECT OF FENITROTHION FOR CONTROL OF WESTERN SPRUCE BUDWORM OKANOGAN NATIONAL FOREST

LEGEND

Single Application	1,4,6
Double Application	5
Control	2,3

FIGURE 3



1975 PILOT PROJECT OF FENITROTHION FOR CONTROL OF WESTERN SPRUCE BUDWORM
WENATCHEE NATIONAL FOREST

LEGEND

Double Application	7,9	
Control	8	